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COMMENTARY

ECONOMIC GROWTH AND INNOVATION

Solving Spectrum Gridlock:
Reforms to Liberalize Radio Spectrum Management in Canada in the Face of Growing Scarcity

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In this issue...

Rising demand from cellphones and other wireless products has highlighted Canada's scarcity of spectrum space. Reforms could liberalize the allocation of spectrum with a market-based approach, enhance efficiency and increase competition.

The Study in Brief

The global proliferation of wireless technology and rising demand for wireless products is straining the capacity of government spectrum allocation systems to keep pace. In Canada, as elsewhere, the ubiquity of cellphones, combined with the growth of such products as wireless emergency responders and television services using wireless technology, has transformed the distribution of limited spectrum space from an arcane technical issue relevant to telecommunications and broadcasting experts to a matter of great national interest.

This *Commentary* provides recommendations for Canadian policy change that will improve spectrum use for the benefit of consumers and other end users.

Spectrum allocation policy reform in Canada is becoming increasingly urgent as new forms of technology change how spectrum is used and as valuable spectrum space soon to be vacated by analog television broadcasts becomes available.

While spectrum reform and renewal is well underway around the world, Canada's approach to date has been cautious. Indeed, auctions that competitively assign spectrum are commonplace around the world, but are nascent in Canada. Meanwhile, Canada also lags behind the market-based initiatives of other countries, notably Australia, the United Kingdom and the United States.

We recommend a number of reforms for spectrum policy in Canada that would liberalize the allocation system, increase efficiency, and introduce greater competition.

First, Industry Canada, which has sole responsibility for management of the spectrum resource, should rely increasingly on spectrum auctions, as they are the best means of assigning scarce spectrum.

Second, it should apply prices to spectrum to better reflect the opportunity cost of holding that spectrum. Releasing underutilized and surplus spectrum for commercial use would generate government revenues and improve competition, leading to lower wireless prices for consumers.

Third, Industry Canada should allow spectrum holders greater flexibility to trade and change the aggregation of their spectrum in secondary markets. This will better allocate spectrum to its most valued use no matter who purchases it initially through an auction.

Lastly, Industry Canada should focus its regulation of spectrum on reducing signal interference while allowing greater common usage of allocated spectrum.

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INDEPENDENT • REASONED • RELEVANT

Personal communications using wireless technology are of vital importance in Canada, where 99 percent of the population relies on cellular coverage. That reliance can be more than a matter of simple convenience. If a traveller is stranded on an isolated highway in the middle of a storm, rescuers can use various radio services, including cellular communications, trunked radio systems (fire and ambulance services) and global position systems to come to the traveller's aid.

Significantly increased demand for such wireless products has strained the outmoded government-run system of spectrum allocation to users and has resulted in gridlock that has artificially constrained supply and driven up prices in the wireless communications market.

In this *Commentary*, we demonstrate how the spectrum gridlock problem has arisen. To do so, we analyze the Canadian 2008 Advanced Wireless Services (AWS) auction, which helps to locate the gridlock problem within the overall spectrum management regime. This enables us to suggest policy choices that will broaden the effort to increase competition and complement existing market-based mechanisms such as auctions or the use of set-asides of spectrum for particular users. Ultimately, we advocate changes to Canadian radio spectrum management policy that will lead to improvements in how radio spectrum is accessed and used, and ultimately, result in benefits for Canadian consumers.

The physics underlying electromagnetic radiation, spectrum policy and spectrum management remains a distant abstraction for all but a few Canadians. Even so, recent radio spectrum auctions such as the AWS auction for cellular phone services and the US 700 MHz band auction completed in 2008 for spectrum previously used by analog television broadcasts – a precursor to a similar auction to be conducted in Canada in the near future – brought welcome public attention to the issue.[1]

The Canadian AWS auction raised $4.26 billion for 105 megahertz (MHz) of radio spectrum, with licences awarded to two classes of bidders: incumbents that already provide wireless services; and new entrants. While some have described the auction as a success, criticism has been levelled in two areas. First, critics pointed to the policy-based preference for new entrants, who received an advantage in that they were provided with a set-aside of spectrum that only they could bid on. As well, critics alleged that auction design flaws resulted in higher than expected prices.

Properly designed auctions are a necessary and effective tool for assigning spectrum. Much of the effort to design better auctions, as with standard applications of antitrust regulation, is intended to thwart unfortunate bidder tendencies: collusion, barriers to entry and exercise of market power.

However, the underlying challenge facing spectrum management in Canada goes beyond auction design. Current administrative methods, whereby the government manages and determines spectrum allocation and use, exacerbate rather than diminish spectrum scarcity. As a result, these methods can introduce gridlock into the process of making spectrum available to meet demands for new services. Further, they create conditions of scarcity that can be exploited in auctions by companies bidding strategically to defend their turf.

The Background

Radio spectrum (hereafter referred to as spectrum) is a subset of the electromagnetic waves lying between the frequencies nine kilohertz (kHz – thousands of cycles per second) to 300 gigahertz (GHz – billions of cycles per second). Spectrum supports a wide range of business, personal,

The authors wish to sincerely thank Björn Wellenius, Ian Munro, and Stuart MacPherson for their valuable comments and suggestions.

1 Industry Canada, the Canadian government department responsible for spectrum management, completed an auction for AWS licences in 2008. In 10 years, auctions have raised almost $6 billion. The 700 MHz band auction in the US was the largest in its history collecting over US $13 billion.

industrial, scientific, medical and cultural activities, both public and private.

Ensuring that radio systems, especially public-safety radio, function properly is a major concern of spectrum managers. In Canada, Industry Canada has this responsibility.[2] The framework for spectrum management has centred on the need to regulate in a way that reduces signal interference and guarantees that bands are available for public-sector uses. While this approach does not imply that growing private-sector needs are neglected, it generally presumes that regulatory decisions, not market forces, are "capable of deciding what uses of spectrum are best for the public (FCC Working Paper, 1980).[3] However, under this historically prevalent interference management regime, radio spectrum has become a potentially scarce national resource.[4]

Until recently, reforming spectrum management has been premised primarily upon enhancing administrative tools and practices such as licensing flexibility, technical standards and the re-assignment of vacated frequencies, known as "refarming." However, with the increased demand for spectrum and the appearance of innovative and efficient technologies, the reform effort has evolved toward a mix of market-based methods, such as administered incentive prices for government-held spectrum,[5] auctions, spectrum trading, the creation of spectrum commons where unlicensed spectrum is made available, and spectrum sharing using advanced radio technologies.[6] Economic considerations are receiving greater priority, with international support. For example, the International Telecommunications Union has noted:

> "As the frequency spectrum is a scarce resource, decisions concerning spectrum management should also consider the economic point of view. Therefore, to improve national spectrum management all available means including economic methods are needed" (International Telecommunications Union 2000).

Frameworks for Spectrum Management

There are two principal spectrum management frameworks: administrative or market based. Under the administrative approach, the regulator makes decisions how spectrum is used and who uses it, usually based on criteria relating to perceived strength of demand, economic and social benefits, and technical efficiency. Under a market-based approach, firms decide through a commercial process how spectrum gets used, subject to broad technical and free-market rules.

The International Telecommunications Union

The international framework for the use of the radio frequency spectrum is set out in a treaty among the member states of the International Telecommunication Union (ITU), a specialized UN agency. The ITU has performed the leading role in ensuring technical compatibility and coordination of global system spectrum

2 Industry Canada has a strong international reputation as a leading spectrum management organization, especially in the area of satellite communications. Canada's willingness to share what it has learned with developing countries has helped bolster this reputation.

3 As one commentator has stated, regulatory "public-interest" determinations suffer from a lack of transparency and are likely to reward the human-capital of the decision-makers (Hazlett 2008).

4 From 1900-1950 there was a one-million-fold increase in the intensity of spectrum use and from 1950-2000 another one-million-fold increase. "Cooper's Law," named after the inventor of the hand-held cellular phone, projects that wireless communications capacity doubles every 2.5 years and each bandwidth breakthrough stimulates additional wireless applications.

5 Administrative Incentive Prices (AIP), discussed later, are additional tools to promote efficiency in spectrum use within a framework of administrative spectrum management. Licences are issued administratively but carry with them an obligation to make a payment to the regulator or government to promote efficient spectrum use – not simply to recover spectrum management costs. The idea is that if a user has unused spectrum, it will choose to return it rather than pay the charge. Also, if a user can pay a lower fee by using spectrum more efficiently, that user may adopt more spectrum-efficient operations.

6 The use of the spectrum commons involving unlicensed (but not unregulated) use of frequencies has led to important innovations relating to spread spectrum and low power applications such as Wi-Fi. The use of the spectrum commons is limited to certain bands representing a very small portion of the overall spectrum below 15GHz.

allocations[7] for such purposes as broadcast, mobile radio, cellular and satellite services.[8] Allocation decisions are made at the international and national level after much consultation among national regulators on the broad purpose or purposes to which particular frequencies will be put (known as making spectrum allocations on either a primary or secondary basis).

US Rules on Spectrum Relevant to Canada

Canada coordinates allocations and assignments with the United States spectrum regulatory authorities that include the Federal Communications Commission (FCC)[9] and the National Telecommunications and Information Administration (NTIA).[10]

The United States has moved in the direction of flexible spectrum use, reflecting generally liberalized practices. In 2002, the FCC's Spectrum Policy Task Force concluded that the administrative model of regulation needed to be largely replaced with increased use of market-based mechanisms. The Task Force Report also identified a key failing of spectrum policy – how administrative rigidities prevent more efficient use of this unique resource.

The report's other key recommendations included:

- providing the maximum-feasible flexibility for licensees, limited only by interference concerns; and
- increasing use of spectrum trading among private spectrum holders,[11] including the ability to lease spectrum.

The United States has held the most spectrum auctions (72) and the most spectrum trades.[12] The magnitude of annual spectrum trades in the US – facilitated in part through a trading market place and database – is significant in comparison to recent auctions such as the FCC AWS auction. A typical way of defining magnitudes in spectrum is to estimate "MHz-pops," or the amount of bandwidth in megahertz[13] times the population covered by the licence. On average, 10 billion MHz-pops of cellular spectrum trade annually from 2003–2008.[14] The AWS auction, which was large in comparison to previous auctions, released 18 billion MHz-pops into the marketplace. The US uses auctions and trading to improve access to spectrum and efficiency of use.

7 An important clarification between spectrum allocations and spectrum assignments is helpful at this point. Spectrum allocations refer to the various types of radio services and spectrum bands associated, ex ante, with the services prior to assigning to users specific frequencies within the allocated bands. Allocations can be made on a primary or secondary basis. A user of a service that has a secondary allocation shall not cause harmful interference to users of a primary service. Furthermore, bands are allocated for services such as broadcast and cellular, whereas frequencies are assigned by way of licences to operators of those services. Assignments can be made on an exclusive or shared basis.

8 Good examples of how the international framework helps to coordinate frequency allocations include consistent frequencies for aeronautical, mobile, radio and cellular communication services. GSM (Global System for Mobile) communications allows one to "roam" and make calls or text messages while using cellphones outside of Canada.

9 The FCC is responsible for managing non-government allocations and assignments, as well as spectrum use while the NTIA is responsible for US federal government allocations and assignments and spectrum use.

10 Services where coordination takes place include broadcast (AM, FM, TV and the move towards digital services), cellular and microwave services. At the spectrum allocation stage, broad decisions on use are made at global and regional ITU radiocommunication conferences. These conferences are usually held every four years, and so the process can take time. For its part, Canada then prepares its own allocation, which usually imposes further restrictions on spectrum. The overall time frame needed to allocate and assign spectrum to new services can easily take 10 years.

11 Spectrum trading is a mechanism whereby rights and any associated obligations to use spectrum can be transferred from one party to another by way of a market-based exchange.

12 The United States leads in auctions with over 70 followed by Australia with 35, New Zealand with 10. Meanwhile Canada had conducted seven spectrum auctions by 2009.

13 As the number of MHz of a spectrum block increases, the greater the capacity of that block.

14 Source: FCC ULS Database.

The UK Experience

The UK telecommunications regulator, Ofcom (www.ofcom.org.uk), is a leading proponent of moving to more market-based methods. With respect to auctions, Ofcom stated in its 2004 Spectrum Framework Review that:

> Auctions are now used as the preferred competitive means for assigning spectrum in many countries. Auctions solve the most pressing problems for many of the regulators – they allow spectrum to be assigned where demand significantly exceeded supply in a way that is demonstrably transparent and far less prone to legal challenge than the alternatives. However, auctions without liberalisation, (liberalisation involves giving greater flexibility in how spectrum is used by a user), cannot let the market decide on the most appropriate use for spectrum. (Ofcom 2004.)

Ofcom goes further by adding:

> [Ofcom envisions]…allowing market forces to prevail through the implementation of trading and liberalisation where possible [by]... fully implementing these policies in around 72 per cent of the spectrum.[15]

Current Spectrum Policy in Canada

Goals

In Canada, responsibility for management of the spectrum lies with Industry Canada through its minister (hereafter referred to as the Minister). The enabling legislation by which the spectrum is managed is the *Radiocommunication Act,* (hereafter referred to as the Act). The Act sets out the powers of the Minister with regard to planning allocations and uses of spectrum, assignment of spectrum to users by way of licensing, other related authorizations and control of interference, etc. The objectives of other relevant legislation – the *Telecommunications Act and the Broadcasting Act* – are to be taken into account by the Minister when regulating spectrum use. The Minister is also required to ensure the integrity and functionality of the telecommuni-cation infrastructure pursuant to provisions developed under the *Emergency Preparedness Act.*

In the broadcasting sector, the Canadian Radio-television and Telecommunications Commission (CRTC) authorizes and regulates radio and television broadcast undertakings for which the Minister issues a broadcasting certificate.[16]

The Minister is also required to ensure the integrity and functionality of the telecommunications infrastructure pursuant to provisions developed under the *Emergency Preparedness Act.* High-level policy objectives are not set out in the *Radiocommunication Act.* Rather, the department's Spectrum Policy Framework (SPF) states the primary objective as being, "To maximize the economic and social benefits that Canadians derive from the use of the radio frequency spectrum resource" (Industry Canada 2007).

To meet this objective, the SPF goes on to state the enabling guidelines, which emphasize the need to employ markets, facilitate spectrum trading and the development of property rights subject to the overriding concern of regulating in the "public interest." Specifically, the policy framework states:

- market forces should be relied upon to the maximum extent feasible;
- spectrum should be made available to support Canadian sovereignty, security and public safety needs;
- spectrum policy and management should support the efficient functioning of markets by:

  (i) permitting the flexible use of spectrum to the greatest extent possible;

  (ii) harmonizing spectrum use with international allocations and standards, except where Canadian interests warrant a different determination;

15 The target was subsequently reduced to 55 percent, which will still represent a massive transfer of frequencies into the domain of markets.

16 The telecommunications policy for Canada is set out in Section 7 of the *Telecommunications Act* while the broadcasting policy is set out in Section 5 of the *Broadcasting Act.*

(iii) facilitating secondary markets for spectrum authorizations;

(iv) clearly defining the obligations and privileges conveyed in spectrum authorizations; and

- notwithstanding the above, spectrum should be made available for a range of services that are in the public interest.

Industry Canada's Role

Domestically and within the international framework described above, Industry Canada through the Minister also sets the policy and regulates the use of radio spectrum, something usually avoided in larger economies.[17] At the highest level, Industry Canada does this largely through its Canadian Table of Frequency Allocations, which sets out what radio services can use which frequency bands and under what conditions. These conditions of use vary widely, from inflexibly reserving particular frequencies for uses that are specified in detail to providing considerable freedom for particular bands or services.

With respect to reform and innovation taking place elsewhere, Industry Canada in developing the Policy Framework for the AWS Spectrum Auction noted "that other countries with competitive wireless markets, notably the U.S. and the U.K., have taken and continue to take measures to facilitate access to spectrum resources and market entry" (Industry Canada 2007).

It is worth pointing out that a prominent federal review panel of telecommunications policy recommended changes to the supervision of spectrum policy in Canada. According to the 2006 Telecommunications Policy Review Panel Report, the authority to regulate Canada's radio spectrum and to license its use should be transferred from Industry Canada to the CRTC.

The purview of Industry Canada is huge, cutting across most industry sectors. Usually, telecommunications and spectrum management reform takes a back seat to other government priorities. Sometimes, though, the issues are very much in the forefront as was the recent case involving conflicting regulatory decisions by Industry Canada and the CRTC over the licensing of Globalive Wireless Management Corp. as a new wireless incumbent. A CRTC decision to bar Globalive from obtaining an operating licence was later overturned by the Federal Cabinet.

What Are the Objectives of Spectrum Auctions?

In our research, we evaluated different telecommunications regulators' handling of auctions (Table 1). One of the poorest is the first-come, first-served approach that assigns available spectrum to users in the order they request frequencies. Lottery-based spectrum assignments that, at first hand, may seem equitable have many drawbacks and have fallen out of favour. One of their principal drawbacks is that they attract rent-seekers who enter the lottery but have no real intention to utilize assigned spectrum. Another problematic method is the so-called beauty contest, also known as comparative review, which involves the regulator deciding who best deserves a spectrum assignment. Such allocations are often opaque and do not allocate spectrum to those who value it the most.

In our view, auctions best support the main regulatory objectives of technical and economic efficiency.[18] Auctions, particularly, represent regulatory best practice for assigning high-value spectrum rights such as cellular and broadcast[19] because:

17 Canadian and Japanese spectrum regulators remain within government ministries whereas other G7 countries established independent spectrum regulators prior to 1999.

18 Technical efficiency refers to maximum utilization of radio spectrum by avoiding interference or large gaps between assigned frequencies, whereas economic efficiency refers to maximizing the value of outputs obtained by use of radio spectrum.

19 Auctions are now being used to effectively assign small, less-valuable spectrum packages such as the recently completed BWA Residual Spectrum Auction conducted by Industry Canada in June 2009.

Table 1: Comparison of Spectrum Allocation Methods

Objectives	First come/First served or Direct Award	Lottery	Beauty Contest	Auction
Efficient assignment of spectrum	Unlikely	Unlikely	Unlikely	Very Likely
Promote downstream competition	Poor	Poor	Poor	Good
Effective and transparent process	Poor – Good	Good	Very Poor	Good
Minimum risk of litigation	Poor	Good	Very Poor	Good
Raising revenue to reflect scarcity	Poor	Poor	Poor	Excellent

Source: InterConnect Communications Limited 2008

- prices set at spectrum auctions are comparatively free from political influence and collusion;
- auctions are comparatively fast in delivering a result;
- operators themselves set the spectrum price rather than the price being set by the regulator, although the regulator can greatly influence prices through selection of auction method;
- market prices can encourage rapid rollout of services by requiring competing operators to quickly extend coverage to generate cash-flow (assuming effective competition takes place); and,
- sound economic principles related to consumer welfare and investment are applied when spectrum is in the hands of those who value it most highly.

In addition to meeting the main objective of achieving an efficient, timely and dispute-free assignment of scarce spectrum when the demand for spectrum exceeds supply, spectrum auctions in Canada meet objectives such as supporting sovereignty, harmonization and competition.

Support Canadian Sovereignty

Industry Canada through auction eligibility criteria and usage rules can take steps to influence how Canadian or foreign-owned entities use strategic spectrum resources.[20] One simple way to improve competition is by loosening foreign ownership restrictions. Canada is one of the few OECD countries placing such restrictions in the telecommunications sector.[21] No less an authority than the Competition Bureau has expressed the view that foreign ownership restrictions represent a considerable and sometimes insurmountable barrier to entry. "They have served their purpose and are no longer necessary to harmonize Canadian policy with that of our global trading partners" (Competition Bureau, 2007).

Indeed, other countries appear to manage foreign ownership without compromising either security or customer interests. In our view, foreign ownership should play no role in spectrum allocations. For example, in the United Kingdom the parent companies of the five mobile operators are headquartered in France, Germany, Hong Kong, Spain and the United Kingdom.

20 The recent government decision to license Globalive as a new wireless telecommunications service provider centred on resolving the issue of Canadian control, not spectrum usage.

21 The only OECD countries with foreign ownership requirements that apply to all companies in the sector are Canada, Korea and Mexico. It is further noted that a Canadian Parliamentary Committee and two expert panels have recommended easing foreign ownership restrictions, but nothing has happened (see OECD Communications Outlook, 2009).

Harmonization

Spectrum packages can be structured to ensure spectrum is used in ways that ensure compatibility with global network systems and that Canadians benefit from economies of scale.

The recent Canadian AWS (2.1 GHz) auction and the US 700 MHz auction are prime examples of plans harmonized between Canada and the United States, both in spectrum availability and packaging. These auctions achieved the explicit goals of economies of scale and coordination of cross-border services that benefited Canadian consumers.

Competition

Spectrum is an essential element of many high-value commercial and public services for which there are not good wireline substitutes. It follows that a company that controls the necessary spectrum also controls the downstream service sold to end-users. Hence, improving access to spectrum reduces barriers to entry into existing and new markets.

Since Industry Canada regulates spectrum access through licensing, it has the key role in lifting the access barrier, subject to domestic and international allocations. There are, however, several other ways in which competition among service providers can be achieved, such as the intervention of mobile virtual network operators (MVNOs)[22] who purchase access to a wireless network's minutes on a wholesale basis and resell them to consumers. Such a system can create a form of competition, providing benefits to end-users from direct spectrum licensing to operators.

In a competitive environment, auctions combined with technology-neutral licensing and service-neutral licensing ensure that resources are efficiently assigned and applied to the introduction of services that benefit end-users. However, if the services market is inadequately competitive, the incumbents can use the auction to exclude further competition.

Evaluation Framework

Whether auctions effectively promote policy goals should be evaluated from both theoretical and practical perspectives.

The Theory

A useful and standard way of evaluating the effectiveness of auctions or any other method of resource allocation is to ask:

- Do auctions promote economy in production? (In the case of spectrum, this would involve asking if some users wasted spectrum.)
- Do auctions promote the production of the right set of goods and services? (For example, is spectrum available to produce the services that end-users want?)
- Do auctions promote innovation? (In other words, is spectrum available for new services?)[23]

Markets, in general, permit the free exchange of labour and land, goods and services, as well as physical, financial and intellectual assets among the households, firms and public organizations in the economy. Because transactions are based on free exchange, markets do not – unlike administrative allocation methods – entail hierarchies with 'deciders' and 'implementers' (although firms operating in a market economy do exhibit such hierarchies internally).[24] From this theoretical standpoint, auctions are more effective.

22 MVNOs are operators that combine their own retail mobile telephony and customer management assets and capabilities with the access and network technologies and spectrum of a traditional wireless operator. Examples of this in Canada include Koodoo (on the Telus network), Fido (on the Rogers network) and Virgin Mobile (on the Bell network).

23 The three underlying resource allocation themes are technical, allocative and dynamic efficiency.

24 Markets are capable of accommodating general restrictions on anti-competitive behaviour and particular consumer protection measures.

The Practice

While auction theory is a triumph of the application of economic theory to economic practice, it has not, in practice, been an unalloyed success. There are numerous examples of famously failed and flawed auctions.[25] Some of the problems include: auctions that appear to be flawlessly designed but are subject to political interference (preferences and reserve prices); the failure to perceive the importance of the interaction of auctions among different countries; and bad advice given by experts who fail to take into account their client's history and strategies (e.g., dominant providers compelled to defend their turf).

There have been spectacular failures in terms of opening bid prices for spectrum, stipulated by the regulator, being set too high. A combination of factors such as inadequate spectrum packages, inappropriate reserve prices, unrealistic expectations by bidders, flawed bidding rules, strategic bidding and collusion by participants can and have caused an auction to fail. Excessive service obligations imposed on successful bidders in terms of rollout can also lead to failed auctions and operations.

CANADIAN AWS AUCTION RESULTS: Industry Canada completed an auction over the summer of 2008 where 105 MHz of highly valuable spectrum, divided into six blocks for use in advanced wireless mobile services, was offered to two groups – incumbents that desired added spectrum and new entrants. After starting with nearly 300 initial bids in May 2008, the AWS auction concluded in Round 331 on July 21, 2008.

Industry Canada had several straightforward goals in mind with the auction:

- increase competition to the benefit of consumers;
- ease entry by providing a set-aside for qualified new entrants; and
- earn a fair return for Canadian bidders.

Our review of results and the bidding activity points to several patterns and behaviours:

1. Bell, TELUS and Rogers, which dominate the Canadian cellular market, won all of the assignments in the top five markets in the open blocks (Blocks A, E, and F). They bid $1.74 billion for 41 percent of the total amount bid ($4.177 billion) for all licences in Blocks A – F (see Appendix A for details of the auctions). The bidding for these assignments concluded early in the auction and was essentially over by round 30;
2. Bidders were most interested in the top five markets in Blocks A – F which accounted for 72 of all bids made ($3.033 billion out of $4.177 billion);
3. As could be expected, incumbents largely bid strategically to protect existing markets by preventing new entrants from gaining a spectrum footprint in the A, E and F bands (the open bands). Rogers dominates Block A, and Bell and TELUS together dominate Blocks E and F;[26]
4. Assignments for new entrants within the set-aside blocks (Blocks B, C and D) ended up being quite fragmented with some areas of regional concentration;
5. One bidder, Globalive, bid the second highest overall to obtain a 10 MHz footprint in Toronto (Block B – $279 million). Globalive was to prove unsuccessful in obtaining a similar 10 MHz footprint in any other major city and is limited to 5 MHz in important markets such as Vancouver, Calgary, Winnipeg and Ottawa.[27] It remains to be seen how this will affect its business model.

Industry Canada unquestionably succeeded in conducting an auction over a relatively short period of time, which has led to few disputes,

25 For an interesting primer on auction theory, design and examples of auctions failures and how auction theory can be abused refer to Klemperer's very readable *Auctions: Theory and Practice.*

26 Industry Canada AWS Blocks A, E, and F auction files were reviewed. Bell, Rogers and Telus were awarded spectrum by bidding highest in the top five markets (by population). See Appendix A.

27 Although imminent technologies such as Long Term Evolution (LTE) can use both five and 10 MHz bands, having more spectrum assigned allows for better performance in terms of cost and speed, which ultimately drives consumer satisfaction and quality of service.

while bringing new entrants into several key markets and raising significant new revenues for the federal government.

Probably the most controversial element was the use of set-asides for new entrants. This issue is addressed in an article prepared for European spectrum and telecommunications regulators (Cave, forthcoming). The argument against set-asides is that in a fully mature spectrum market regime, it is probably unnecessary or even harmful to intervene to promote competition by such mechanisms.

With a technological- and service-neutral spectrum market covering a substantial number of mobile communications frequencies from 400 MHz to 3.5 GHz, spectrum availability should not be a barrier to entry. However, many countries now moving toward a market-based spectrum approach may be restrained by past, possibly dysfunctional, policies. As an illustration, the mobile market in Canada is often characterized as a tight oligopoly, which some experts say has served consumers poorly.

Where past administrative practice has generated inequalities in spectrum holdings, an appropriate regulatory response may be to impose spectrum caps, or limits to the amount of spectrum that can be held, which prevent the best endowed operators from extending their dominance. The European spectrum and telecommunications regulators note that "caps at spectrum awards are thus seen by some as offering an effective form of intervention which can, under the right circumstances, benefit end users (ERG-RSPG 2009)." Thus, the UK government intends to impose spectrum caps on the prospective "digital dividend" (UK, 2009). Other European spectrum regulators, in the Netherlands for example, are also turning to this approach.

Where past regulatory policy (in Canada's case, both spectrum and foreign ownership restrictions) has imposed an artificial brake on entry, a different approach may be required. In such circumstances, there is risk that a standard auction will produce an outcome of no change: all available spectrum will be acquired by existing operators.

The use of set-asides in the AWS auction was a means, available within a very limited time period, of introducing new players into the market, leading to the prospect of enduring benefits for consumers. Absent the set-asides, these benefits might not have been possible. Even with them, they may not materialize. The application of the policy was a judgment call, the correctness of which cannot yet be evaluated. But while such measures should not be necessary in the long run, they can help during the transition of the market from a highly regulated status quo to a better and more competitive future.

Improving auction design is only a partial answer to the fundamental underlying problems. An auction delivers a once-and-for-all assignment of spectrum to those who believe they can use it most profitably, but it lacks a mechanism for constant adjustments to the ownership and use of frequencies necessary to ensure continuous innovation. Administrative methods worked well for decades, but now they account for the gridlock problem.

Options for Reform

We consider two proposals to alleviate Canadian spectrum gridlock: reducing scarcity and improving access. The first involves spectrum pricing to promote efficient use and the second involves the creation of markets based on the free exchange and flexibility in the use of spectrum.

Pricing Spectrum Increases Availability

Studies in other jurisdictions have shown that significant amounts of allocated and assigned radio spectrum are underutilized. A 2005 spectrum audit conducted for the UK government found that government departments and entities held approximately 50 percent of the spectrum below 15 GHz[28] with significant evidence of underuse.[29] Several policy measures were taken subsequent to the study to reduce the amount of spectrum held by the government and to increase

28 This is the area of the usable spectrum that facilitates most cellular transmission.

29 As reported in the Independent Audit of Spectrum Holdings submitted in 2005 by Prof. Martin Cave to the UK government (often referred to as the Cave Audit), UK government holdings of spectrum approximate 50 percent of all of the spectrum below 15GHz.

the efficient use of spectrum that remained in the hands of all users, including the government. First, specific targets and time frames were established for auditing and planning the release of spectrum from government hands. Secondly, prices (known as administrative incentive prices or AIP) were attached to use of the spectrum. These prices were explicitly intended to reflect the scarcity of the spectrum, not the administrative costs of managing it.

AIP thus reflect the opportunity cost for spectrum in a particular use compared to alternative uses. They ensure that all radio spectrum are priced, regardless of who uses it, and that spectrum is priced at a level that serves to encourage efficient use. By combining targets with better pricing, radio spectrum becomes available and is used efficiently (see Ofcom 2009 for an evaluation).

What Model of Spectrum Management Is Best?

We have already pointed out that the traditional administrative method assumes that the regulator/spectrum manager plays a direct role in assigning the spectrum to users and in choosing the technology and service model for how the spectrum is accessed and used. This is in contrast to using spectrum markets to ensure spectrum assignment is decentralized to market forces – those that use it make those decisions.

In a spectrum market, radio spectrum itself becomes tradable. Licences are treated as private property, and the licensee has control over who is allowed to share that spectrum. An important aspect of the spectrum property right is the duration of the licence term. The duration choice involves compromises between two competing public-policy outcomes: firstly, the desire to maintain uninterrupted investment incentives so as to eliminate disincentives to invest toward the end of a licence period; and secondly, the regulator's ability to influence spectrum use and, if necessary, to redefine property rights to accommodate new technologies.

The trade-off noted above between investment incentives and sovereignty can be resolved by giving the regulator, in the case of long or infinite licence duration, powers, subject to specific conditions, to re-acquire licences by compulsory purchase. These powers might be exercisable in cases of:

- a security, defence or other national emergency;
- a need to redefine spectrum user rights to accommodate new technologies such as ultra-wide band (UWB) and cognitive radio;[30] and
- a change in international agreements or treaties.

The regulator's mandatory acquisition of spectrum would have to be accompanied in all cases by an economic cost-benefit analysis and a demonstration that the benefit of the technology could not be attained by ordinary commercial transactions among rights holders.[31]

In addition to obtaining flexible exclusive rights and longer terms of licence duration, primary users (licensees) clearly benefit from strong interference protection for their exclusive use.[32] The core characteristics for exclusive-use licences are that they must be tradable and amenable to division and aggregation. Tradable licences have several

30 The ITU defines UWB in terms of a transmission from an antenna for which the emitted signal bandwidth exceeds the lesser of 500 MHz or 20 percent of the centre frequency. Due to the extremely low emission levels currently allowed by regulatory agencies, UWB systems tend to be short-range and indoor applications. Cognitive radio refers to new technologies that "sense" other frequency users and automatically vacate the spectrum for unused spectrum.

31 Spectrum valuation studies are periodically conducted by regulators when comparing the value of specific spectrum bands in alternative uses. AIP, which was described earlier as a means to "price" spectrum, can offer an indication of spectrum value in alternative uses.

32 The reference to this regulatory approach as "exclusive use" reveals a high level of confusion by policymakers. For example, cellular band allocations are some of the most intensely shared frequencies (measured in net economic value generated). No one bids billions of dollars for licences to obtain "exclusive use," but they do to exercise "exclusive rights" so as to enable diverse non-exclusive spectrum access for subscribers, application providers, technology suppliers, and rival networks. For example, in Canada innovators like Research in Motion (RIM) or Apple contract for access to wireless networks. Their products such as BlackBerries and iPhones then deliver wireless functionality to millions of customers despite being developed by firms lacking licences or other spectrum assets.

In RIM's case, it effectively buys tiny frequency slices, bundled with wireless network connectivity, in bulk from mobile carriers. RIM's BlackBerry customers are then able to consume billions of minutes of network access. RIM produces and sells radio devices (BlackBerries) and maintains computer networks that route content (in particular, email messages) to and from mobile carriers, which then relay this valuable content to BlackBerry users. Subscription revenue is then split between RIM and the carrier.

beneficial implications. First, if licence ownership is subject to transfer, then it is continuously possible for market forces to provide incentives for spectrum to be allocated to its highest value use. Whatever the use, it will reflect true opportunity cost. Together, these factors produce powerful incentives to use spectrum efficiently. Second, the more spectrum that is tradable in this way, the more liquid will be secondary markets and the lower will be the average opportunity cost or scarcity rents associated with access rights. Encouraging spectrum prices to be as low as possible, consistent with aggregate demand and supply factors, will enable low-cost access for new applications and services, clearly a major goal of spectrum reform.

With respect to aggregation, there may need to be controls to protect against the creation of undue market power by a small number of firms who may act to deny rivals access to spectrum. A regulatory upper limit on the amount of spectrum acquired by dominant market players (spectrum caps) is one mechanism for protecting against excess aggregation. If spectrum caps are adopted, they should be relatively loose (sometimes referred to as adjustable or soft caps) and should be linked to other findings of market power.[33]

Nobel economics laureate Ronald Coase's critique of the legacy model of regulation anticipated and outlined the basic elements of a spectrum market based on well-defined property rights. But it took three decades before his suggestions began to be put into effect (Coase, 1959).[34]

A future where market processes are pure and unfettered is unrealistic, since any market will inevitably be subject to some form of regulation. The real estate market is quite open and serves as a useful analogy. Real estate markets include a mix of different frameworks for ownership (government and commercial; public and private) and uses encumbered by various obligations (i.e., responsibilities not to pollute) and limitations (i.e., zoning bylaws, rights of way and restrictive covenants).

As well, the need to manage legacy transition issues, protect against harmful interference and promote the public interest will require ongoing regulation. However, relative to the traditional framework, we should be better off when regulation becomes less administrative and more market-based, relying on general competition law, bargaining and adjudication processes to manage a well-defined framework of rights (Coase 1960).

How can Canada Improve its model of Spectrum Management?

A significant part of spectrum is used to provide services that are clearly in the public interest. These services have traditionally been allocated by administrative methods. Administrative methods were a viable way of managing and assigning spectrum in the past but there are doubts about whether the approach remains necessary or efficient. Government can improve efficiency and access if it puts a price on spectrum and allows permit trading and the disposal of any surpluses. As well, organizations producing services in the public interest should be required to prepare for more output, as needed, and be responsible for acquiring (and given the means to acquire) the necessary spectrum at market prices.

The government's use of radio spectrum to provide services similar to those provided by the private sector should, at a minimum, be subject to market prices or opportunity cost. Moreover, these services should be tradable in secondary markets.

A foreseeable exception is government's use of spectrum to meet national security needs and international treaty commitments. This spectrum is not likely to become subject to market-based assignments but should be subject to market prices.

33 There are several problems with spectrum caps. Should they always apply? and for how long? The regulator typically can waive soft caps if, for example, they prevent an operator from deploying innovative low-cost services. Useful information on spectrum caps can be found in Little's "Mobile Broadband, Competition and Spectrum Caps."

34 Coase's discussion of spectrum allocation was the precursor of his more general demonstration that bargaining among agents could lead to efficient outcomes despite the presence of externalities, if private property rights were well defined and the costs of bargaining were zero. Subsequent literature has explored a variety of factors which effect whether private bargaining can eliminate inefficiencies from externalities, including the nature and impact of positive transactions costs, the impact of different structures of property rights, the interaction of taxes and bargaining, the possibility that some participants possess private information, the effect of no convexities and the implications of endogenous participation. The bargaining he described is often referred to "Coasian bargaining." In a spectrum context, it would mean that parties could trade on a bilateral or multilateral basis to optimize their combined returns from the frequencies they jointly possess.

Having a well-defined framework of usage rights will be an important step to enable market-based assignment. The exclusive-use licence defines the rights to occupy a given block of spectrum. Primary users have a presumptive right to exclude other users from occupying their frequencies. Secondary users may have the right to occupy the frequency if they can do so without causing interference to primary users, although they have no interference protection rights of their own.

The question of how best to manage shared access to the radio frequency spectrum while providing appropriate interference protection is important for all users. The focus of spectrum management should, therefore, be on providing adequate protection in a market framework or, in some cases, a spectrum commons.

The goal of licensing reform should be to strip away all aspects of the administrative regime that are not related to interference management in a market-allocation framework. Prime examples for elimination are buildout or rollout requirements for licences and service or technical restrictions that are not consistent with and motivated by interference protection.[35]

The steps taken by Industry Canada to allow transferability of spectrum since its 2007 review represent an improvement, but are only an incremental change relative to the sort of divisibility and transferability anticipated in the reforms recommended here (see Industry Canada 2009). However, within the more restrictive current framework, the revised licensing procedures leave much to be desired. Generally, they apply only to Personal Communication Service (1900 MHz) and cellular licences (AWS) awarded by auction, and other licences on a case-by-case basis. The procedures that allow Industry Canada to review every transfer can impose uncertainty, unnecessary bureaucratic delays and costs, thereby increasing spectrum-access transaction costs and hamper the sort of flexibility and secondary trading that the reform is designed to enable.

With respect to duration, Canadian spectrum licences typically have a 10-year time span and a 10-year extension with a reasonable expectation of renewal beyond these 20 years. The choice of an expiry date, be it five, 10 or 20 years hence, is always somewhat arbitrary.

An argument in favour of granting longer or perpetual spectrum usage rights is that investment occurs in stages, and each investment has a different payback period. Regulators and the public at large have difficulty placing complete trust in unfettered market forces. Therefore, the regulatory authority usually retains the option of withdrawing spectrum usage rights. In our view, longer-term arrangements (15 to 20 years), on balance, are more favourable as they offer better investment incentives and involve a clearer definition of a licensee's rights.

Recommendations

We have several policy recommendations:[36]

1. The Canadian government should recognize that efficient spectrum management is crucial to the country's economic prosperity. Although senior ministers and public servants may find it challenging, it is essential that they understand what is at stake. As discussed in the sections of this paper on spectrum policy goals and outcomes, auctions will achieve the best outcome for spectrum users.
2. Radio spectrum, like other inputs into productive processes in a market economy, should carry a price that ensures that all users – public and private sector alike – use it effectively. As we have noted, the United Kingdom has implemented such a pricing scheme. The Canadian government could begin such a process through consultations and preparation of a draft policy statement.
3. Canada should specifically adopt policy directives leading to the implementation of secondary markets, enabling spectrum trading along with flexible user rights. Both the experience elsewhere and economic theory show that such tradability will improve how spectrum is used.

35 Limiting choice of 3G to W-CDMA for a new band would be a mistake since this is not required to protect interference. Another example would be a band plan consideration such as bandwidth, which can limit the licensee's choice in technology.

36 For each of these main recommendations more detailed guidance is provided in a study prepared by the authors (see Industry Canada 2007).

Appendix A

Successful Open Block Bidders in the Top Five Markets

City	Block A 10 MHz	Price ($millions)	Block E 5 MHz	Price ($millions)	Block F 10 MHz	Price ($millions)
Toronto	Rogers	$235	Telus	$103	Bell	$314
Montreal	Rogers	$192	Bell	$128	Telus	$234
Vancouver	Rogers	$117	Bell	$62.1	Telus	$117
Ottawa	Rogers	$46.5	Bell	$33.2	Telus	$44.6
Edmonton/Calgary[a]	Rogers	$35.4	Bell	$19.2	Telus	$57.4

Successful Closed Block (for New Entrants only) Bidders in the Top Five Markets

City	Block B 10 MHz	Price ($millions)	Block C 5 MHz	Price ($millions)	Block D 5 MHz	Price ($millions)
Toronto	Globalive	$279	Delta Audio Video	$131	Quebecor	$96.6
Montreal	Quebecor	$168	Quebecor	$112	Quebecor	$96.4
British Columbia	1380057 Alta Ltd	$101	Globalive	$67.4	Delta Audio Video	$56.4
Eastern Ontario	Quebecor	$51.9	Delta Audio Video	$30.4	Globalive	$27.1
Saskatchewan/ Winnipeg[b]	Sasktel	$40.4	Sasktel	$24.2	Globalive	$13.5

[a] Edmonton was the top five market for Blocks A and E. Calgary was the top five market for Block F.
[b] Saskatchewan was the top five market for Blocks B and C. Winnipeg was the top five market for Block D.
Source: Industry Canada.

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